MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2018/2019

DMT5028 – CONTROL SYSTEMS

(Diploma in Electronic Engineering)

16 OCTOBER 2018

9:00 AM – 11:00 AM

(2 HOURS)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **5** pages (excluding the cover page, appendix and graph papers).
2. Answer **ALL** questions. All necessary working steps **MUST** be shown.
3. Write all your answers in the answer booklet provided.

QUESTION 1 [20 marks]

(a) A certain system is described by the differential equation:

$$\frac{d^2c(t)}{dt^2}+5\frac{dc(t)}{dt}+6c(t)=\frac{dr(t)}{dt}+r(t)$$

where $r(t)$ and $c(t)$ are the input and output of the system, respectively. Assume zero initial conditions.

(i) Find the system transfer function.

[4 marks]

(ii) Find the response $C(s)$ to the input $3e^{-4t}$.

[2 marks]

(iii) Obtain the initial value using the Initial-Value Theorem.

[2 marks]

(iv) Find the final value using the Final-Value Theorem.

[2 marks]

(b) Consider the signal flow graph shown in *Figure 1-1*. Use Mason's gain formula to find the system transfer function.

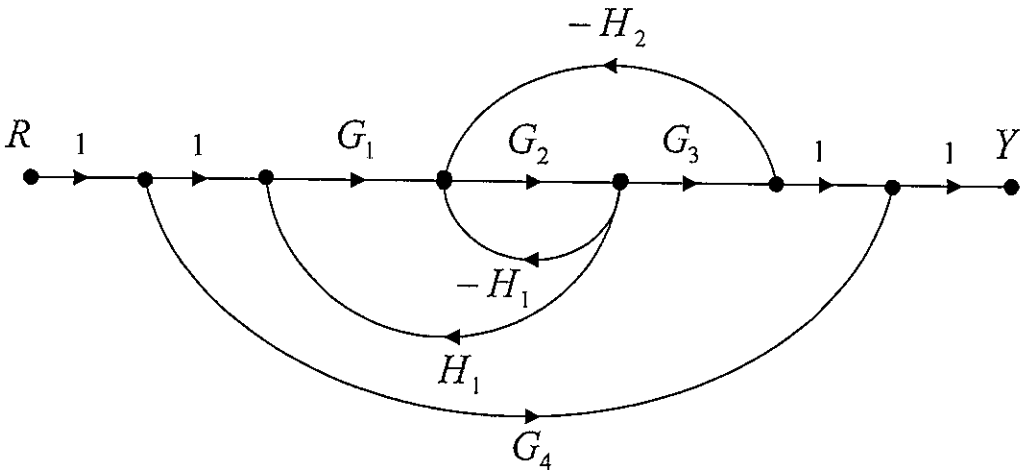


Figure 1-1

[10 marks]

Continued ...

QUESTION 2 [20 marks]

(a) Draw the free-body diagrams and write their respective equations of motion for the mechanical system shown in *Figure 2-1*.

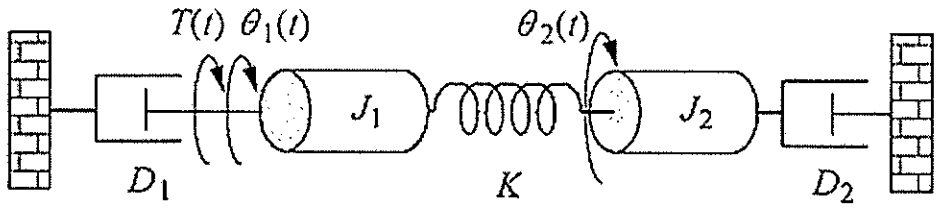


Figure 2-1

[9 marks]

(b) A rotational mechanical system with gears is shown in *Figure 2-2*. Determine the transfer function $\theta_2(s)/T(s)$.

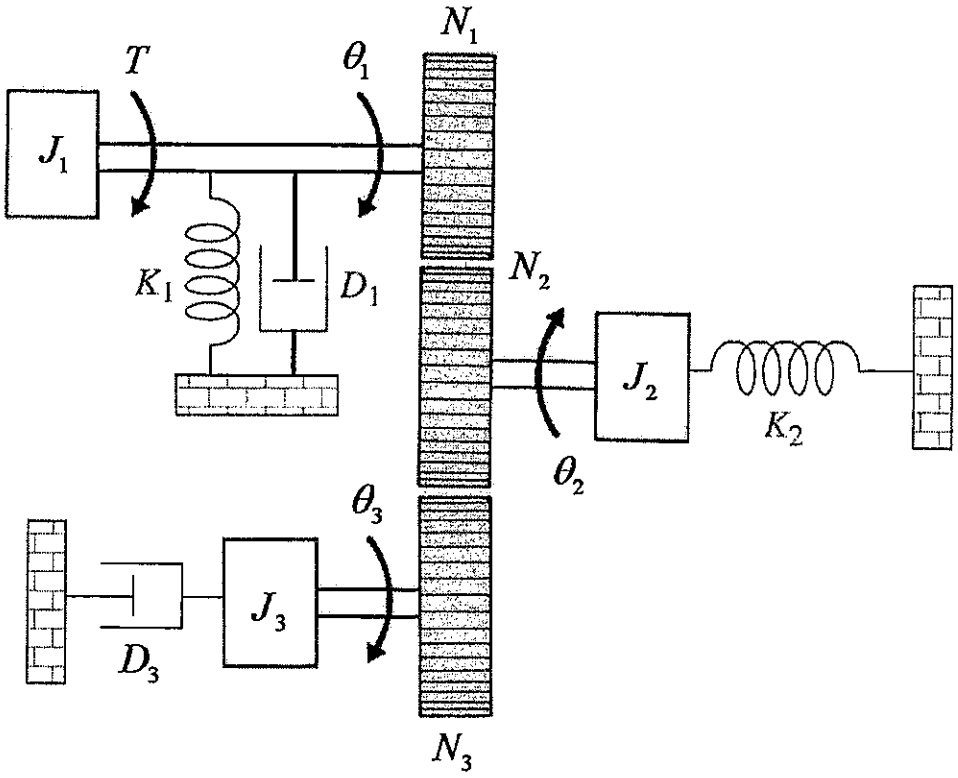


Figure 2-2

[11 marks]

Continued ...

QUESTION 3 [20 marks]

(a) Given the second-order control system with the following closed-loop transfer function:

$$T(s) = \frac{13}{s^2 + 3s + 13}$$

Find ω_n, ζ, t_s, and percentage of maximum overshoot.

[7 marks]

(b) Consider the following forward-path transfer function of a unity-feedback control system:

$$G(s) = \frac{2s + 16}{2s(s^2 + s + 1)}$$

(i) With the aid of Routh-Hurwitz criterion, show that the system is unstable.

[7 marks]

(ii) Determine the number of roots that are located in the right-half of the s-plane.

[2 marks]

(iii) Find the steady-state error for a unit ramp input.

[4 marks]

Continued ...

QUESTION 4 [20 marks]

Consider a unity-feedback system whose open-loop transfer function is:

$$\frac{K}{(s^2+12s+32)(s-2)}$$

(a) Determine the following:

(i) The angles of asymptotes and centroid's location.

[2 + 2 marks]

(ii) The $j\omega$-axis crossing points.

[9 marks]

(iii) The breakaway point(s).

[4 marks]

(b) Construct the complete root loci of the system.

[3 marks]

Continued ...

QUESTION 5 [20 marks]

Construct the asymptotic magnitude and phase Bode plots on the given semi-log graph papers for the following open-loop transfer function of a system. Show the logarithmic magnitude and phase angle of $G(j\omega)$ for all of the basic factors appeared in the system.

$$G(s)=\frac{400}{s(2s+20)(2s+4)}$$

Note: Use the two (2) semi-log graph papers provided at the end of this question paper. Attach the two (2) semi-log graph papers to your answer booklet.

[6 + 14 marks]

End of Page

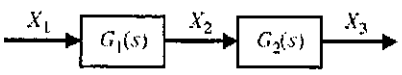
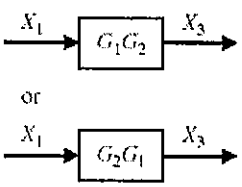
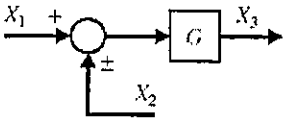
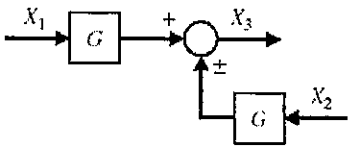
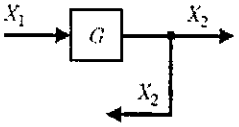
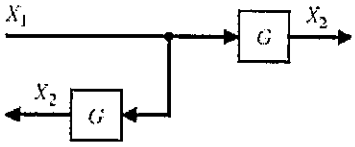
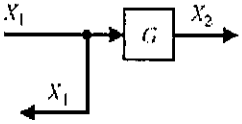
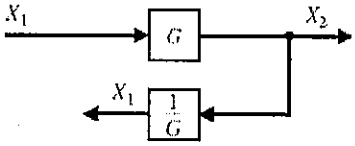
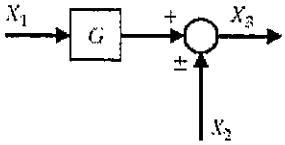
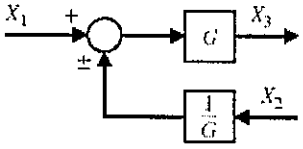
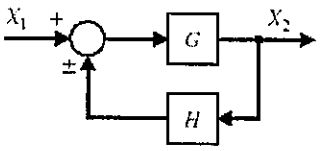
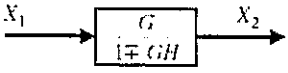
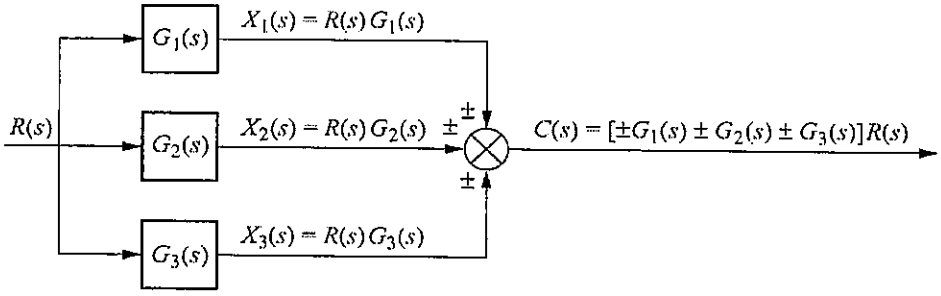
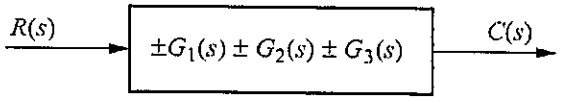
APPENDIX

(A) Laplace Transformation of some basic functions

$f(t)$	$L\{f(t)\} = F(s)$
$\delta(t)$	1
$\mu(t)$ or 1	$\frac{1}{s}$
t	$\frac{1}{s^2}$
t^n	$\frac{n!}{s^{n+1}}$, $(n = 1, 2, 3, \ldots)$
e^{-at}	$\frac{1}{s+a}$
$t\,e^{-at}$	$\frac{1}{(s+a)^2}$
$t^n\,e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$, $(n = 1, 2, 3, \ldots)$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$

$f(t)$	$L\{f(t)\} = F(s)$
$t \sin \omega t$	$\frac{2\omega s}{\left(s^2+\omega^2\right)^2}$
$t \cos \omega t$	$\frac{s^2-\omega^2}{\left(s^2+\omega^2\right)^2}$
$e^{-at} \sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$
$\sinh \omega t$	$\frac{\omega}{s^2-\omega^2}$
$\cosh \omega t$	$\frac{s}{s^2-\omega^2}$
y'	$sY(s) - y(0)$
y''	$s^2Y(s) - sy(0) - y'(0)$
y'''	$s^3Y(s) - s^2y(0) - sy'(0) - y''(0)$

(B) Block Diagram Transformation Table

Transformation	Original Diagram	Equivalent Diagram
1. Combining blocks in cascade		
2. Moving a summing point behind a block		
3. Moving a pickoff point ahead of a block		
4. Moving a pickoff point behind a block		
5. Moving a summing point ahead of a block		
6. Eliminating a feedback loop		
7. Combining blocks in parallel	Original diagram:  Equivalent diagram: 	

(C) Formulas for Time Response Parameters

a) $\frac{Y(s)}{R(s)} = \frac{{\omega_n}^2}{s^2 + 2\zeta\omega_n s + {\omega_n}^2}$

b) maximum overshoot $= y_{\max} - 1 = e^{-\pi\zeta/\sqrt{1-\zeta^2}}$

c) percentage of maximum overshoot $= 100e^{-\pi\zeta/\sqrt{1-\zeta^2}}$

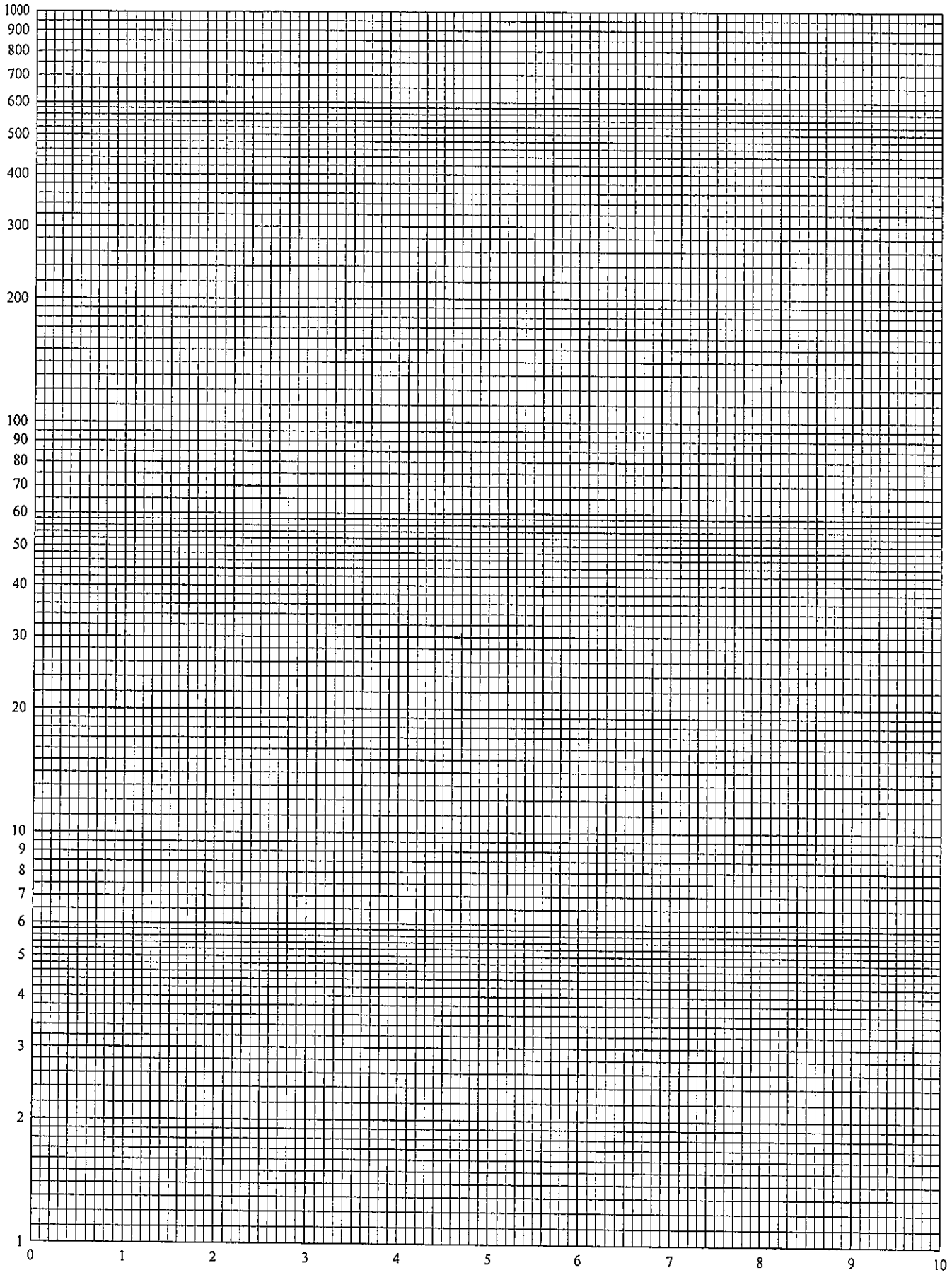
d) $t_{\max} = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

e) $t_d \cong \frac{1+0.7\zeta}{\omega_n} \quad 0 < \zeta < 1$

f) $t_r = \frac{0.60+2.16\zeta}{\omega_n} \quad 0 < \zeta < 1$

g) $t_s = \frac{3}{\zeta\omega_n}$

Semi-log Graph Paper



Semi-log Graph Paper